Resource use and costs for a glaucoma screening program in Austria: An 8-year review.

A cost-consequence analysis based on the Salzburg-Moorfields Collaborative Glaucoma Study

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PURPOSE. *The aim of this study is to report costs, detection rates, and resources needed for detection of primary open angle glaucoma and related diseases in a glaucoma screening program in Salzburg, Austria, over a period of 8 years.*

METHODS. *The Salzburg-Moorfields Collaborative Glaucoma Study performed a complete ophthalmologic examination on a total of 4864 subjects within a study period of approximately 8 years (98 months). The total numbers reported are total number of subjects screened at the initial examination and follow-up examinations; total working hours and estimated working hours per visit for one ophthalmologist and two medical assistants; direct costs per visit; detection rates for subjects; and corresponding costs per true positive case diagnosed with definite primary open angle glaucoma (POAG), early POAG, POAG suspect, ocular hypertension (OHT), and glaucoma artefact.*

RESULTS. *Within the screening period of 98 months, a total of 9427 examinations and second verification checks were performed: 5466 at the initial examination, 404 at the 1-year follow-up, 815 at the 2-year follow-up, 339 at the 3-year follow-up, 225 at the 4-year follow-up, 1059 at the 5-year follow-up, 996 at the 6-year follow-up, 118 at the 7-year follow-up, and 5 at the 8-year follow-up. The total amount of time spent for screening was 23,814 working hours. We estimate the costs per visit at EUR 123 for each initial examination, EUR 28 for each second confirmation check, and EUR 95 per follow-up examination. The following detection rates were observed: definite POAG: 1.7% (95% CI: 1.3–2.2%), early POAG: 2.9% (95% CI: 2.3–3.5%), POAG suspect: 8.5% (95% CI: 7.6–9.4%), OHT: 2.2% (95% CI: 1.7–2.7%), glaucoma artefact or other causes: 5.8% (95% CI: 5.1–6.6%), normal cases: 79% (95% CI: 78–80%).*

CONCLUSIONS. *Direct costs per visit were considerably higher than those reported in the Netherlands or the United Kingdom. If a health care provider decides to perform a glaucoma screening within this setting, the costs for the detection of a new case are EUR 7250 for definite POAG, EUR 4250 for early POAG, EUR 1450 for POAG suspect, EUR 5600 for OHT, EUR 2100 for glaucoma artefact case, and EUR 156 for a normal case. (Eur J Ophthalmol 2006; 16: 92-99)*

KEY WORDS. *Costs, Economic, Evaluation, Glaucoma, Resources, Screening*

INTRODUCTION

For purposes of planing policy strategies in the medical field, an assessment of the costs for the prevention and the management of glaucoma is becoming increasingly important, as the average life expectancy as well as the number of older people is steadily increasing in many European countries. Official population projections provided by EUROSTAT - the Statistical Office of the European Community - predict a considerable increase in Europe's senior population. From 2000 to 2030, the number of residents over 70 years will increase by about 48% in Germany, 50% in Norway, 54% in Greece, 55% in Switzerland, 80% in Luxenbourg and 81% in the Netherlands (*). In Austria, one out of five residents was over 60 years in 2001, but every third resident will be over 60 years old in 2035 (**).

Several studies focusing on the relation between age and prevalence of glaucoma (1-5) demonstrate an increasing prevalence of the disease with increasing age. As a consequence of age-dependent prevalence and the increasing number of older residents in the near future, the total cost for managing and treating primary open angle glaucoma (POAG) and related diseases will increase within the next decades. These developments will lead to a large variety of consequences for the health care systems in Europe, consequences that are difficult to predict for diseases with age-dependent prevalences. Moreover, with the increase in required glaucoma therapies, economic considerations, such as the comparison of alternative uses of available resources, are becoming mandatory. Therefore it will become inevitable for medical professionals in clinics and practices to consider rising costs and the effectiveness of current accepted medical principles.

On one hand, most studies on costs and management of glaucoma address the issue of medication (6-8), hospitalization and surgery (8, 9), clinic charges (8), disease stability (10), laser treatment (11), and total costs reviewed from the tertiary care glaucoma practices (12). The use of resources and the costs associated with diagnosis and treatment of glaucoma and ocular hypertension (OHT) have previously been reported in the Netherlands (13).

On the other hand, comparatively little is known about the total cost, the effectiveness, and the benefit of glaucoma screening programs. Important results were published by the Netherlands Glaucoma Patient Association that organized a glaucoma screening study to investigate the total cost of a low-cost glaucoma screening program (14). Another important approach focused on the cost-effectiveness of various modes of screening for POAG in the United Kingdom (15). Based on the different designs of screening programs, the corresponding costs vary considerably, e.g., the costs per true positive case were estimated to amount to USD $850 per true POAG in the United Kingdom (15) and to approximately EUR 1160 per glaucoma in the Netherlands (13).

It is the aim of the present study to report the costs, resources used, and detection rates of POAG and related diseases within the study period of approximately 8 years (98 months).

The questions addressed in this study are as follows:
* How many subjects were screened at the initial examination, a second verification check, and follow-up examinations?
* How many working hours were spent on the screening program?
* What is the corresponding cost per visit for an initial examination, second check, and follow-up examination, if personnel costs and costs for medical equipment are concerned?
* Which detection rates of definite POAG, early POAG, POAG suspects, OHT, artefacts or other causes, and normal cases were observed in our screening program?
* What are the costs per true positive case for definite POAG and related diseases (early POAG, POAG suspects)?
* How do direct costs change when subjects are screened in three different screening modes: a wide-meshed screening, a close-meshed screening, and a medium variant?

METHODS

Description of the SMCGS

The Salzburg-Moorfields Collaborative Glaucoma Study (SMCGS) is embedded into a 10-year glaucoma

blindness prevention program for the Federal State of Salzburg in Austria. This glaucoma screening program focuses mainly on information provision, identification of glaucoma suspects, and treatment of clear-cut cases of glaucoma. Within a study period of approximately 8 years (98 months), a total of 4864 individuals of the SMCGS were screened. A detailed description of this population-based screening study and its intention as a preventive medical checkup has been published previously (16). Briefly, in accordance with the design of the SMCGS, the inclusion criteria in this program are age 40 years, best spectacle corrected visual acuity >6/9 (at distance), refraction ranging from –6.00 to +4.00 diopters, and difference in refraction between both eyes <3.00 diopters. The exclusion criteria comprised the following conditions: pseudophakia, glaucoma therapy at the initial examination, eye diseases that can lead to visual field defects or a secondary increase of intraocular pressure (IOP), contraindication against beta blockers, systemic corticosteroid therapy, or pregnancy.

The examinations included a complete eye examination including refraction, best-corrected visual acuity, applanation tonometry (Goldmann), biomicroscopy of

TABLE I - OVERVIEW OF THE NUMBER OF INDIVIDUALS SCREENED AT THE INITIAL EXAMINATION, SECOND CHECKS, AND FOLLOW-UP EXAMINATIONS IN THE SMCGS WITHIN APPROXIMATELY 8 YEARS (98 MONTHS)

Type of examination	Number of individuals screened	Included in the SMCGS*	Second checks	Totals
Initial examination	4864	3517	602	5466
1-year follow-up	339	272	65	404
2-year follow-up	700	390	115	815
3-year follow-up	230	217	109	339
4-year follow-up	178	162	47	225
5-year follow-up	881	816	178	1059
6-year follow-up	867	820	129	996
7-year follow-up	100	90	18	118
8-year follow-up	5	3	0	5
Totals	8164	6287	1263	9427

*Meeting the inclusion and exclusion criteria of the study
SMCGS = Salzburg-Moorfields Collaborative Glaucoma Study

TABLE II - ESTIMATED TIME SPENT ON INITIAL EXAMINATION, SECOND CHECKS, AND FOLLOW-UP EXAMINATIONS IN HOURS FOR ONE SUBJECT AND IN TOTAL EVALUATION PERIOD OF MEDICAL STAFF

Medical staff	Estimated amount of time per patient (in hours)			Estimated amount of time in hours within approximately 8 years (98 months)			
	Initial examination	Second checks	Follow-up	Initial examination	Second checks	Follow-up	Totals
1. Medical-technical assistant	1.1	0.3	0.7	5350	379	2310	8039
2. Medical-technical assistant	0.9	0.1	0.7	4378	126	2310	6813
Ophthalmologist	1.1	0.3	1	5350	379	3300	9029
Totals	3.1	0.7	2.4	15,078	884	7920	23,883

The gross income is standardized to an age of 30 years and is based on personnel department of the university hospital
Estimates of medical technical assistants and ophthalmologists include informing the patient, medical examination, phone calls, data entry, and all other organizational activities

the anterior segment, fundus examinations with assessment of the optic nerve head and the subjective cup-to-disc ratio (a subjective C/D ratio was defined as normal if it was less than 0.4, suspect if 0.4 < C/D ratio   0.6, and abnormal if C/D ratio was larger than 0.6), history of existing eye diseases, and current topical treatment. Furthermore, the Visual Field Test Analyzer (Humphrey Visual Field Test Program: 24-2 full threshold,

Humphrey Instruments, Inc., San Leandro, CA, USA) was used to calculate the glaucoma hemifield test (GHT) which assesses a visual field as normal, borderline, or abnormal. A reliable test of the visual field was defined as having fewer than 33% fixation losses. Each eye indicating a glaucomatous visual field defect was retested in second checks after 3 and 6 months respectively to confirm the glaucomatous visual field defect. GHT data of individuals with non-normal subjective C/D ratio (> 0.4) or IOP   22 mmHg were sampled. A normal GHT was assigned by definition to an eye with a normal subjective C/D ratio and a normal IOP (modified GHT). At the ophthalmologist's discretion, a nerve fiber layer analysis was performed for subjects at risk with the Glaucoma Detection System (GDx, Laser Diagnostic Technologies, Inc., San Diego, CA, USA). Second verification checks of individuals were performed in case

of an increased IOP (IOP > 21 mmHg) and/or pathologic visual field after 3 months and/or 6 months after the initial or follow-up examination.

Diagnosis criteria for glaucoma and related diseases

There is much debate regarding the diagnosis of various types of glaucoma. In order to work with the diagnostic criteria suggested by the European Glaucoma Society, we follow the European Guidelines for Glaucoma (17) and adhere to the following definitions: definite POAG: POAG normal pressure glaucoma, POAG high pressure glaucoma; early POAG: early POAG normal pressure glaucoma, early POAG high pressure glaucoma; OHT: ocular hypertension; normal: normal; POAG suspects: all other diseases. The criteria were applied to both eyes. Finally, individuals were classified based on the diseases on the worse eye.

Data sources

Two different data sources were used: 1) data from the SMCGS within a study period of about 8 years (98 months); 2) data provided by the controlling depart-

TABLE III - OVERVIEW OF ASSUMPTIONS AND ESTIMATED DIRECT COSTS FOR 1000 INDIVIDUALS IN THREE DIFFERENT SCREENING MODES

		Screening mode*		
Follow-up	**Subjects**	**Wide-meshed**	**Medium variant**	**Close-meshed screening**
Every 5 years	Stream 1	Normal case, artefact or other causes, POAG suspect	Normal case, artefact or other causes	Normal case
Annual	Stream 2	OHT, early POAG, definite POAG	POAG suspects, OHT, early POAG, definite POAG	Artefact or other causes, POAG suspect, early POAG, definite POAG
Detection rates	Stream 1	93.3% (±1%)	84.8% (±1%)	79.0% (±1.3%)
	Stream 2	6.7% (±0.8%)	15.2% (±1.2%)	21.0% (±1.4%)
Estimated cost†	Stream 1	118,000	107,000	100,000
	Stream 2	35,000	77,000	106,000
	Totals	153,000	184,000	206,000

*Stream 1 is screened at the initial examination only, while stream 2 is screened at the initial examination and annually within a period of 4 years
†Costs for second check visits are included
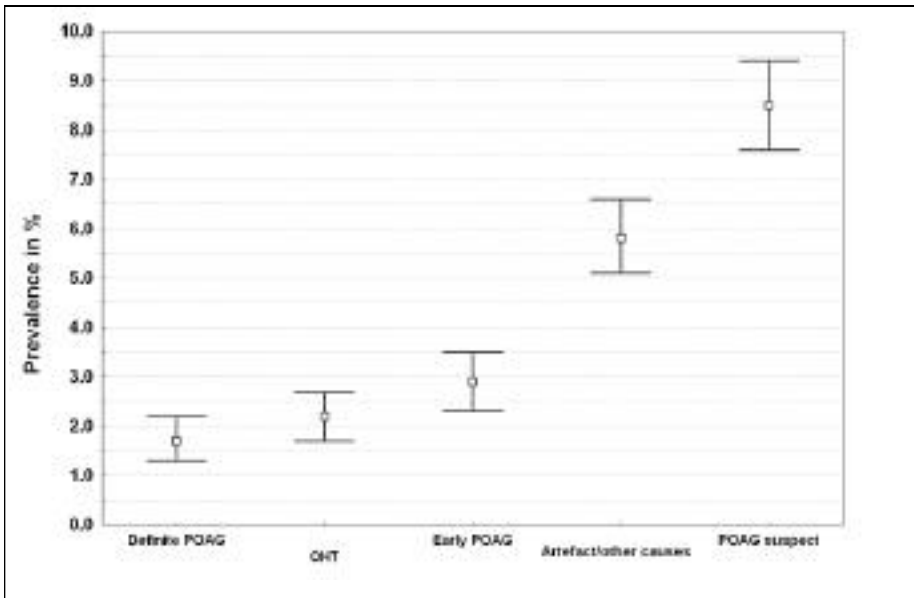POAG = primary open angle glaucoma; OHT = ocular hypertension

Fig. 1 - *95% Confidence intervals for detection rates for individuals diagnosed with definite primary open angle glaucoma and related diseases. Definitions are according to the European Guidelines for Glaucoma (17).*
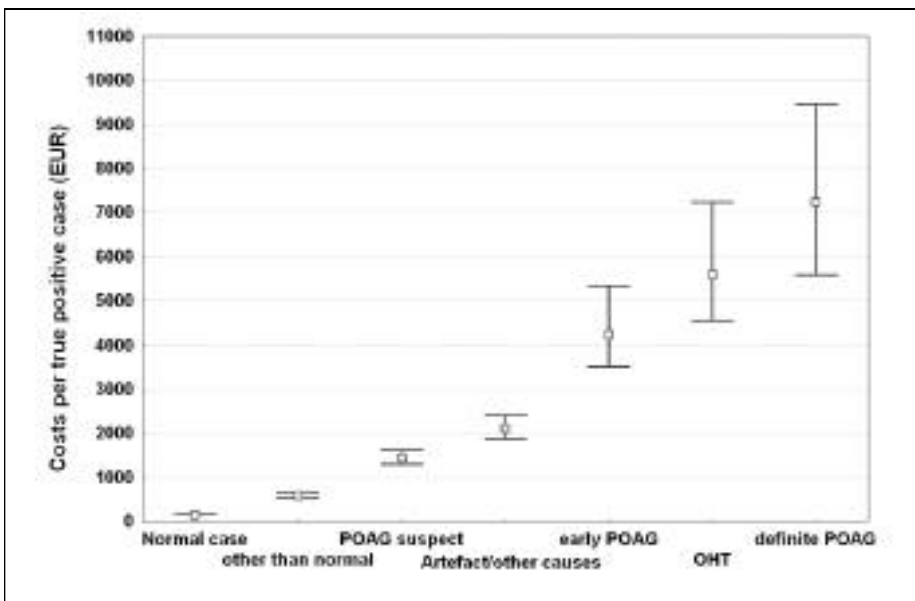

Fig. 2 - *Lower and upper bounds for the cost per true positive case of definite primary open angle glaucoma and related diseases.*

ment of the government hospital regarding personnel cost and investments for the medical equipment of the glaucoma department involved.

Definition of costs

• Direct costs per visit – Direct costs are the sum of the following:
Personnel costs: one resident ophthalmologist and two medical assistants. For the screening program, the medical doctor worked 3 days per week for 8 hours/day, the first medical assistant worked 3 days a week for 8 hours/day, the second assistant worked 3 days a week for 6 hours/day. Direct costs comprise medical examinations and include informing the patients, phone calls, data entry, and all other organizational activities. Direct costs per visit are estimated for the initial examination, second checks, and follow-up examinations. Total purchase costs of medical equipment (inventory) of the glaucoma screening department.
• Costs per true positive case diagnosed with POAG, early POAG, POAG suspect, OHT, glaucoma artefact,

and normal are the direct costs multiplied by the number of subjects screened to detect one diseased case.

Definition of three different screening modes

The total clientele is divided into two different streams of patients. Stream 1 is screened at the initial examination only, while stream 2 is screened at the initial examination and annually over a period of 4 years. According to the criteria of division, three different screening modes are considered:

Wide-meshed screening: Stream 1 consists of normal cases, artefact or other cases, and POAG suspects; stream 2 consists of OHTs, early POAGs, and definite POAGs.

Medium variant: Stream 1: Normal cases, artefact and other cause cases; stream 2: POAG suspects, OHTs, early POAGs, definite POAGs.

Close-meshed screening model: Stream 1: normal cases; stream 2 comprising all other diseases. Detection rates for stream 1 and stream 2 together with direct costs per individual in both streams are estimated.

RESULTS

Number of subjects screened: An overview of the number of subjects screened at the initial examination, second checks, and follow-up examinations is given in Table I.

Working hours spent for the screening program: Based on information provided by the personnel controlling department, the total amount of working hours amounted to 23,815 hours, of which the ophthalmologist used 9,016 hours, the first medical technical assistant worked 8,036 hours, the second medical assistant 6,762 hours. When combining these numbers with the observed number of individuals at the initial examinations and follow-up examinations, the time spent for the initial examination, second checks, and follow-up examinations can be estimated (Tab. II).

Costs for an initial examination, second checks, and follow-up examination: The total cost for medical personnel was about EUR 759,950; the cost for inventory is about EUR 189,550, resulting in a total direct cost for personnel and inventory of EUR 950,500. If

applying the results of Table II, estimations for the direct costs per visit result in EUR 123 per initial examination, EUR 28 per second check, and EUR 95 for every follow-up examination.

Detection rates of POAG and related diseases: Figure 1 illustrates the detection rates for individuals diagnosed with definite POAG, early POAG, POAG suspect, OHT, and artefact or other causes, based on observations at the initial examination.

The corresponding direct costs per true positive case are illustrated in Figure 2.

Comparison of three screening modes: The results of the comparison of total direct costs and estimated detection rates for three different screening modes are given in Table III.

DISCUSSION

Comparison with the results of other glaucoma screening studies:

Netherlands: Niessen et al (14) initiated a study in 1991 and evaluated the effectiveness of a low cost screening setting. During a screening period of 8 days, 1259 subjects over the age of 49 years were screened by non-ophthalmologically trained students supervised by a glaucoma specialist. Individuals with glaucomatous visual fields were re-examined. Glaucoma was diagnosed in 16 individuals. The cost of this screening set-up was estimated at HFL 48.60 (EUR 22.05) per screening. If our screening setting is applied and we assume that the prevalence is the same in both populations, one can expect to find 24 cases of definite POAG (95% CI: 18–30 definite POAG cases). Low-cost screening is an interesting approach, but much more research has to be done to design an optimum low-cost screening with sufficiently high sensitivity and specificity rates.

United Kingdom: Tuck and Crick (15) investigated the cost effectiveness of various modes of screening for POAG based on a model population. This simulation study assumes a prevalence of POAG of 1.2% in the model population of white patients age 40 and over, which is in good correspondence with our results for definite POAG. The authors suggested different screening modes routinely using ophthalmoscopy and tonometry, with perimetry routinely or

selectively on all groups with high glaucoma risk. The cost per true positive glaucoma was estimated at US $850 – which is considerably lower than our estimates for POAG (EUR 7235). However, this difference may be owed to our inclusion of medical equipment. The authors state that perimetry (Henson CFS 2000) takes an average of 4 minutes per individual, whereas in our setting the visual field analysis (Humphrey, 24-2 full threshold) takes about 16 minutes per individual. In addition, in our setting, subjects were screened with TopSS and GDx technology, which increases costs for inventory and time.

Comparison of total costs and resources in three different modes of screening

The wide-cost screening mode assigns 93.3% to be screened at the initial examination (only once) and 6.7% of all individuals at the follow-up examinations for up to four times (e.g., annually). If 1000 individuals are screened, about 933 individuals are screened in stream 1 and 67 in stream 2. The direct costs for 1000 individuals in stream 1 are EUR 118,000 and EUR 35,000 in stream 2, resulting in a total cost of EUR 153,000. The corresponding cost of the medium variant amounts to EUR 184,000, i.e., about 20% more, and the cost of the close-meshed screening is EUR 206,000, i.e., about 35% higher than that of the wide-meshed screening. At present, it is not sufficiently clear which of the screening modes would be the easiest to implement. For every screening, it is important to assess the cost-benefit ratio. At this point, however, the benefit of screening cannot be assessed with sufficient validity.

Outlook/economic questions remaining to be addressed in future research

Benefit of screening: Is it possible to reduce health care expenses induced by glaucoma disability by a glaucoma screening program? It would be most desirable to have a model at hand that estimates the benefit of diagnosis, second checks, and treatment, given different risk factors such as IOP level, status of the optic nerve head, age, and visual field of a subject. An interesting step in this direction was found by AGIS (18) who investigated the association between control of IOP and disease progression (visual field

deterioration) after surgical intervention. However, at the moment, the available epidemiologic data are not detailed enough to allow a well-founded estimate of the risk of becoming blind with and without treatment at given levels of IOP, age, race, thin cornea, and other risk factors in a screening setting. Only with such a link can the actual benefit of diagnosis and treatment be estimated to clarify whether glaucoma screening is a good investment.

Management of patients with no, low, and high risk: How can the total number of individuals be split into two or more streams of patients in order to minimize the costs for follow-up examinations and to maximize sensitivity and specificity? Which individuals at risk should be controlled in a close-meshed grid (e.g., annually or biannually), which ones in a wide-meshed set-up (e.g., every 5 years)? It would be important to compare the respective costs with the corresponding benefits of different screening modes.

Different entry age for the screening program: Our screening program is offered to individuals at age 40 or above. Can it be justified to set a higher age threshold for a screening program, and how many overt cases of high risk or actual disease would be overlooked? It would be very valuable to set up cost and benefit scenarios for screening programs with a higher entry age.

CONCLUSIONS

This analysis reports the estimated prevalences for POAG and related diseases of a screening study of more than 3500 individuals fulfilling the inclusion and exclusion criteria of the SMCGS in Austria. The 95% confidence intervals are 78–80% for normal cases, 5.1–6.6% for artefacts or other causes, 1.7–2.7% for OHT, 7.6–9.4% for POAG suspects, 2.3–3.5% for early POAG, and 1.3–2.2% for definite POAG. Within our screening setting, the total amount of time per individual spent by an ophthalmologist and two medical assistants (including administrative work) is 3.1 hours at the initial examination, 0.7 hours for a second check, and 2.4 hours at each follow-up examination. The direct costs per visit are EUR 123 at the initial examination, EUR 98 for second checks, and EUR 95 for a follow-up examination. Although the total direct costs for various screening modes are reported, it is impossible to give a well-founded decision between

different screening modes at this point. A cost-benefit analysis is necessary to assess the benefit of screening and to set up a glaucoma screening program with a high cost-benefit ratio.

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